Assessing practical work in GCSE science
Science Council submission to Ofqual

1 The Science Council

1.1 The Science Council is a membership organisation of learned societies and professional bodies, and currently has 41 member organisations drawn from across science and its applications: a list of current member bodies is attached. Collectively member bodies represent almost 500,000 individual members, including teachers across 5-19 education, scientists, and senior executives in industry, academia and the public sector. The Science Council awards the professional qualifications of Chartered Science Teacher (CSciTeach), Chartered Scientist (CSci), Registered Scientist (RSci) and Registered Science Technician (RSciTech).

1.2 In addition to providing a mechanism for the sector to work collectively, the Science Council develops and leads collaborative projects working with member bodies and the wider scientific community: examples include the Future Morph website[1] designed to provide young people with information about careers opportunities, and LMI analysis of the UK Science Workforce[2].

1.3 The Science Council is the leading UK voice on the skills and professionalism of scientists. Its strength comes from its ability to be multi and inter-disciplinary in its approach to identify the changing nature of science skills needs and challenges facing society.[3]

2 The importance of practical assessment in science GCSE

2.1 The major challenges facing the world, for example, food security, climate change and water scarcity, demand a multi-disciplinary approach to seeking solutions. In addition a host of new areas promising future innovation, such as bioengineering or biophysical chemistry, require interdisciplinarity. Learning by undertaking practical activity yields valuable real life examples of the interplay between science disciplines; teachers need to be supported and resourced to make the most of these opportunities.

2.2 One of the primary functions of GCSE science is to enthuse, excite and equip students with the necessary skills and knowledge to progress to further academic study, vocational education and training or other post-16 qualifications. The inclusion of practical work is a key component of attracting young people into science[4] and is particularly important for those learners who may consider a future working in science.

2.3 The Science Council has defined science as:

> "*the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence"*

The definition purposely emphasises the fact that science is as much a practical activity as it is a theoretical one, and the two elements complement each other. It is important to appreciate that science is not just an academic pursuit and not all learning can be derived from a book. Students therefore need be given the opportunity to experience the application of science directly through practical activities and experimentation. This will help them advance their skills in the handling and manipulation of scientific instruments, and improve their observational skills. These skills can only be gained and eventually mastered through practical activities. In addition to facilitating an awareness of science in practice, practical activities can provide an excellent opportunity to show how biology, chemistry and physics interact, the connection to other sciences and the multidisciplinary nature of science.

2.4 Attracting more young people into science is critical to meeting the UK's future demand for STEM skills. However there is concern that many young people do not have adequate opportunity to experience hands-on science[5] before they make choices about pursuing a future in science. Recent research studies[6] [7] have shown that there is lack of connection between young people enjoying science and visualising a future for themselves as a scientist. Practical activity also

[1] www.futuremorph.org
[2] *The current and future UK science workforce* TBR, Sept. 2011 http://www.sciencecouncil.org/content/science-workforce
[3] http://www.sciencecouncil.org/sites/default/files/UK%20Digital%20Skills%20Taskforce_Science%20Council%20evidence%20submission.pdf
[4] http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtvm052732.pdf
[5] http://www.score-education.org/media/11805/score%20resourcing%20secondary.pdf
[6] https://www.ipsos-mori.com/Assets/Docs/Polls/pas-2014-main-report.pdf
[7] Edgar, Nelson Important but not for me 2005

plays a key role in helping to raise awareness of the value of technical skills and the employment settings in which they can be applied. One of the knock-on effects of young people not having opportunities to experience hands-on science has been that science employers have expressed deep concern about the lack of practical and technical skills at all levels, including graduates[8] across the economy. **Ofqual does not provide any evidence to suggest that its proposals will alleviate these concerns; indeed the science community's concern is that they may exacerbate them, which will be extremely damaging to the long-term health of UK science.**

3 The Science Council has a number of reservations about Ofqual's proposals. We address them in turn below.

3.1 The consultation document states that written exams will draw on students' practical experience, and will give students that have gained practical experience an advantage over those without. This presumes that teachers will be given appropriate incentives to teach a minimum number of practical activities, but it is unclear where the incentives are to stop some teachers from coaching their students to be able to answer written exam questions relating to their practical skills and knowledge. Although the proposals state that there is no limit to the number of activities a school can make available to its students, there is no clear motivation for schools to teach more than the minimum, and **it is more important that students gain experience of high-quality rather than high-quantity practical science.**

3.2 Teachers and schools need to have adequate curriculum time set aside and access to appropriate resources to undertake meaningful practical activity. However, **without greater investment in schools it will still be the case that many schools without access to adequate equipment and resources will not be able to undertake high-quality practical activities**. This will be regardless of whether science teachers have the best intentions to teach exciting and inspiring practical work. Anticipating that many schools will carry out the minimum 8 activities, awarding bodies will need to ensure that each one of the 8 are sufficiently diverse and wide-ranging enough to provide students with expose to as many different types of activity as possible.

3.3 We welcome the recommendation that students keep a log book: doing so will help promote good practice in students keeping track of their learning and development. However it is unclear how teachers will ensure students keep them up to date in conjunction with their other teaching and administrative duties. Furthermore it is uncertain what, if any, penalties schools will incur if they do not or cannot make available students' workbooks to the required standard on request to the relevant examination board.

3.4 Ofqual needs to be clearer on the different types of evidence that exam boards can accept from schools and students to demonstrate their completion of practical work. Indeed **we ask Ofqual to better articulate what it means by the term 'complete'.** Ofqual also need to be mindful of the impact on students that move schools midway through their GCSE's and ensure that their achievements in practical science are transferrable across exam boards.

4 The unintended consequences of changes to practical assessment

4.1 It is hard to imagine a quality science education that does not incorporate experience of practical experiments for all learners. Any qualification needs to have credibility with a range of stakeholders. Given that practical experiments are so essential to science, a **science qualification that can be achieved with no demonstration of knowledge or skills in practical work is unlikely to be valued by students, teachers, parents, further and higher education providers, professional bodies and employers.**

4.2 The Government has stated its intent to move assessment at GCSE level from modular to linear. This will now mean that an entire two-year curriculum will be assessed in a small number of written examinations. **Written examinations are therefore likely to lead to students being questioned on a very limited range of practical skills and knowledge**. If the consultation's proposals are put into effect, it is unclear how a wider range of practical skills and knowledge can be suitably assessed without introducing a further exam that assesses only students' practical skills and knowledge. Much will also depend on the standard of written questions in assessing

[8] http://www.cbi.org.uk/media-centre/press-releases/2014/07/employers-want-education-system-to-better-prepare-young-people-for-life-outside-school-gates-outside-school-gates-cbi-pearson-survey/

practical skills and we wait with great interest the range and standard of activities that Awarding Organisations determines appropriate.

4.3 Under Ofqual's preferred option, future science students will be able to progress from GCSE to A level and into higher education or employment without ever being directly assessed on their practical skills. This will be highly detrimental to all students as they will not have been exposed to and mastered the required skills to undertake particular scientific tasks. It will **discriminate against students looking to pursue more vocationally-focused pathways post-16, such as apprenticeships as those students are unlikely to have acquired the necessary competencies demanded of employers.** It will also provide a demonstrable advantage to students better able to articulate their understanding of scientific concepts through written work compared to students that learn best through hands-on experiences.

4.4 Under the current proposals at least 15% of questions in the written exam will draw on students' experience and knowledge of practical science. It appears possible that a student could still attain a first-class grade without being required to demonstrate any knowledge of practical activity in a written exam. A mark lower than 15% would mean students would not need to demonstrate as much practical science knowledge to achieve a high grade. **The Science Council recommends that Ofqual raise the proportion of marks given to assessment of practical skills and knowledge, and examine the practicalities and impact of separating marks for practical and non-practical written exam questions so that the maximum mark a student can achieve for the non-practical questions is capped.** At the very least this may provide an incentive for teachers to teach practical work to a good standard if they understand that students' may be penalised in exams for having little or no knowledge of practical work.

4.5 Greater consideration needs to be given to resolving what would happen to students who do not complete the required number of practical assessments, and whether they will be eligible to take the final exam. Preventing students who have not completed the required number of practical assessments from taking the written exam may encourage teachers to deliver practical activity in some form. While we recognise that this will penalise some students through no fault of their own, there needs to be significant incentives for teachers to complete the required number of practical activities if the proposals become reality.

4.6 The proposed assessment objectives place too much emphasis on students' ability to recall knowledge and understanding of scientific techniques and procedures, and many of the proposed requirements in relation to apparatus and techniques stress the need to demonstrate a process of 'doing' rather than a process of 'thinking'. A student's ability in a written exam to describe the physical construction of an experiment does not necessarily mean that they have understood or are able to apply that process to a scientific concept. **Students should be taught to learn how to think scientifically, to develop their investigative skills and critical thinking faculties.** Increasing the weighting of the 'application' and 'analysis and evaluation' objectives in written exams would further incentivise teachers as it would mean that students would be required to demonstrate these skills; to do so effectively under exam conditions students would have has to develop these skills throughout the previous two years of study.

5 The level of mathematics in practical assessment

5.1 Mathematics acts as a tool and a language for science. All Science Council Member Bodies emphasise the importance of mathematical skills to their discipline, and recognise that science and mathematics are intrinsically inter-linked. In 5-19 education it is essential that the two strands of science and mathematics work effectively alongside each other achieving coherence in the sequencing of topics.

6 The need for a political consensus on education policy

6.1 To achieve positive, long-term change in public service delivery, proposed reforms need to have the support of all political parties, yet there does not appear to be any political consensus for reform to science GCSE's. **It is significant that a number of senior politicians have voiced concerns about the decision to remove practical assessment from science qualifications**, including the Education Secretary[9], the science minister and the shadow science minister[10]. We also understand that members of the House of Commons Science and Technology Select

[9] https://www.gov.uk/government/speeches/nicky-morgan-why-knowledge-matters
[10] http://sciencecampaign.org.uk/?p=15900

Committee have written to the Education Secretary echoing her concerns. Other bodies such as the Wellcome Trust, the Nuffield Foundation, and the Gatsby Foundation[11] have expressed concern about the proposed changes. All have agreed that the removal of practical work from GCSE *and* A level science risks harming the next generation of UK scientists and the UK economy.

6.2 The Science Council understands that the reason the consultation period is shorter than the standard 3 months is so that Ofqual can ensure the Government's timetable for education reform is adhered to. Thus, the timetable for consultation and subsequent policy change has more to do with political considerations[12] than any thought for the long-term impact on science education, UK science and skills. This is disappointing and unhelpful. **A decision of this nature, with its myriad knock-on effects and potential unintended consequences requires lengthier consideration, a thorough evidence base and longer and wider consultation with the relevant stakeholders.**

6.3 We recognise that no system of assessment will be perfect, but there is no strong evidence base to suggest that an alternative method of assessing practical skills, such as the one proposed by Ofqual, would provide students with a greater enjoyment and understanding of science and scientific concepts and the skills and knowledge to progress further, or provide a more robust and accurate method of assessment. **Ofqual does not appear to have identified any potential drawbacks in the option it is proposing, despite doing so for all the other options suggested and subsequently rejected.** Informal feedback from partner organisations suggests that the science community – and we include science teachers in this[13] - would have liked to have been given longer to consider the proposals and their implications. We look forward to working more closely with Ofqual in the future to iron out any flaws in the existing system of practical assessment.

6.4 Any changes made to the assessment of practical work in GCSE science will need to be monitored extremely closely. While we are opposed to Ofqual's suggested changes, if implemented the **Science Council recommends that a regular review of the impact of the proposed changes is undertaken after implementation by Ofqual, to identify what effect the reforms are having on student uptake of science at and beyond GCSE; the impact on recruitment of science teachers and their enthusiasm for science; and the long-term impact on the availability of practical and technical skills in the workforce.** If there are indications that fewer young people are taking up GCSE science because of changes to policy there needs to be an immediate re-appraisal of how the assessment of practical work is undertaken.

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[11] http://www.nuffieldfoundation.org/sites/default/files/files/2015%2001%2008_Practical%20Science%20GCSE%20Ofqual.pdf
[12] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/278308/sos_ofqual_letter_060213.pdf
[13] http://www.sciencecouncil.org/10-types-scientist